Argument Schemes and Critical Questions for deciding upon the Viability of a Human Organ for transplantation

Pancho Tolchinsky and Ulises Cortés

Polytechnic University of Catalonia
{tolchinsky,ia}@lsi.upc.edu

Abstract. In this document we present an extensive list of argument schemes and critical questions intended to enable agents to argue over the viability of a given human organ. These schemes can be regarded as a domain specific argumentation dialog game, in which the Critical Questions of a given scheme determine the possible dialog moves. In order to represent the wide list of Argument Schemes and Critical Questions in a comprehensible manner we propose in this report a novel formalization of the argument schemes interaction

1 Introduction

In this document we present an extensive list of argument schemes and their associated critical questions to be used by agents to argue over the viability for transplantation of a given human organ. The aim is that, by capturing a sufficiently wide range of reasoning patterns, the schemes will enable and direct the agents in their collaborative decision making. The context of the agents' deliberation is given in [7].

Argument schemes can be regarded as reasoning patterns, structures of inference, possibly nonmonotonic and nondeductive, that enable to identify and evaluate common types of arguments used in a particular domain. Associated to an argument scheme are critical questions that on the one hand identify valid lines of reasoning that can further support the argument instantiating the scheme and on the other hand identify the arguments that attack this argument.

In the construction of the argument scheme repository we introduced a novel formalization that enables to easily define the argument schemes interaction. In the following section we briefly describe the context in which this argument-based deliberation take place. In section 3 we give the basics of the argument schemes and we describe the notation to be used in writing the repository. In section 4 we provide the extensive list of the argument scheme and their associated critical questions. In section 5 we give our conclusions.

2 Arguing Over the Viability of a Human Organ for Transplantation

Within a hospital, when a patient becomes a potential donor, the *Transplant Coordinator* is responsible of determining which of the donor's transplantable organs are viable for that purpose and offer for transplantation the organs deemed as viable. The organ offers are managed by the local *Transplant Organization* which intend to allocate the offered organs to a suitable potential recipient. The organ assignations are made via the *Transplant Units* responsible of the potential recipients. The *Transplant Units* are responsible of successfully transplanting the offered organs. In [7] we propose a human organ selection process in which the *Transplant Coordinator* (TC) offers not only the organs deemed as viable but also the ones considered non-viable, this time however, the offered organs will not be accompanied only by the donor's and organ's characteristics but also by the arguments that support TC's belief to whether the organ is or is not viable. Also, prior to the allocation process, each *Transplant Unit*[1] (TU) will be able to contra-argue TC's argument. In particular, a TU providing valid arguments would be able to label an organ as viable even though the TC deems it as non-viable. As a result, the organs labelled viable will be offered for allocation, via the *Transplant Organization* to all the TU who deemed the organ as viable. Namely this new process enables TUs to rescue organs that would have been discarded by the TC. In [7] besides providing a more in depth description of both, the current human organ selection process and the proposed one, we frame the proposed process in CARREL [8], an agent-based organization designed to improve the overall transplant process. Thus, the arguments of TC and TU, are managed by the agents *Transplant Coordinator Agent* (TCA) and *Transplant Unit Agent* (TUA) respectively. The *Mediator Agent* MA evaluates the agents' arguments and gives the final decision, whether the organ should be labelled viable or non-viable to each TUA. The argumentation formalization are described in [7] and [3].

3 Argument Schemes an Critical Questions

Argument schemes capture reasoning patterns used in a particular domain. This reasoning patterns are in fact, structures of inference. Although argument schemes can capture monotonic deductive inference, such as *modus ponens*, their interest aspect is their suitability to encode nonmonotonic and nondeductive resoning [6]. Argument schemes enable to identify and evaluate common types of arguments used in a particular domain. Associated to an argument scheme are critical questions that on the one hand identify valid lines of reasoning that can further support the argument instantiating the scheme and on the other hand identify the arguments that attack this argument.

[1] The information of the organ offer will only be sent to Transplant Units that are responsible of a potential recipient to whom the offered organ is suitable

Take the argument scheme *Appeal to Expert Opinion* that captures a sensible reasoning, or argumentation, pattern:

AEOS Appeal to Expert Opinion Scheme:
P is an expert in domain D (1)
And P asserts A to be true (2)
And A is in domain D (3)
Therefore A is true.(4)

The critical questions associated to this scheme are:

(CQ1): Is P an expert in domain D?
(CQ2): Did P actually asserted A?
(CQ3): Is A in domain D?
(CQ4): Is P reliable?

Typically, Critical Questions (CQ) are regarded as defeaters of the argument instantiating the scheme ([10] [5] [9] [2]). Namely, if the scheme is instantiated by the argument $A1$:

john is an expert in domain *medicine* (1)
And *john* asserts *mary_is_healthy* to be true (2)
And *mary_is_healthy* is in domain *medicine* (3)
Therefore *mary_is_healthy* is true.(4)

The above CQs capture the possible attacks on $A1$. Whereas -Is *john* and expert in *medicine*?- challenges $A1$, -*john* is unreliable- attacks $A1$ (in fact undercuts $A1$ [4]). Note that there could be one or several schemes that conclude with the claim -*Therefore P is unreliable*-[2], for example the [GAH] scheme:

GAH Generic Ad Hominem Argument:
Person P is bad (1)
Therefore P is unreliable (2)

which is an adaptation of a Walton's *Generic Ad Hominem Argument* scheme [11]. Thus, the argument $A2$ that instantiates this scheme with $P = john$, attacks $A1$ (Pollock undercuts). In general, any argument instantiating [AEO], is attacked by argument instantiating [GAH] such that both instantiate the variable P equally. Hence, all the schemes with the claim -*P is unreliable*- can be regarded as associated to CQ4.

Notation 1: We will write as [AEO](john, medicine, mary_is_healthy) the argument instantiating scheme [AEO] with $P = john$, $D = medicine$ and $A = mary\_is\_healthy$. The order of the arguments of [S-name](X_1,...,X_n) is the order

[2] The last line of an Argument Scheme is the scheme conclusion or claim, the other lines are the scheme premisses. E.g. in [AEO], lines (1), (2) and (3) are the premisses, and line (4) is the scheme claim

of their occurrence in the scheme [S-name]. Note that words starting with small caps are constants, otherwise they are variable.

In this report we propose to consider critical questions not only as defeaters of a scheme, but as both, "*defeaters*" and "*supporters*". In other words, to a CQ of a scheme S1 we also associate the schemes that enable instantiation of arguments which claims are assumptions of an argument instantiating S1. For instance we associate to CQ1 of [AEO] any scheme that concludes with -*Therefore, P is an expert in domain D*-. For instance, the scheme [EbT]:

EbT Expert because of Title:
Person P has title T (1)
And people with title T are experts in domain D (2)
Therefore, P is expert in domain D (3)

In this occasion argument $A3$ = [EbT](*john*, *degree_medicine*, *medicine*), supports premise (1) of the $A1$ argument.

Needless to say, that to [GAH] and [EbT] we can also associate the appropriate CQs. Hence, as pointed out in [9], CQ provides a dialectical nature to the argument scheme. In particular, CQs can be viewed as the allowed moves in a dialog game. Namely, given a proponent argument A that instantiates scheme S, an opponent player could challenge A by instantiating one of S's CQs, or attack A if he is able to instantiate appropriately an attacking argument scheme $S_{attacks-S}$ associate to a CQ of S. The proponent, on the other hand, can instantiate the supporting schemes of S associated to its CQ in order to either answer to a challenge on A, or simply to further support A.

In order to represent the allowed moves of the dialog game, via argument schemes and critical questions, in a readable fashion we propose a novel notation which we found very useful in representing the argument-based deliberation of our scenario.

3.1 A formalization for an Argument Scheme based Dialog Game

In constructing a repository of argument schemes an their associated critical questions for the agents to argue over the viability of a human organ, we found in the literature little help on how to represent a considerable amount of schemes that were associated via CQ. Also, when developing the new notation we felt a requirement from our working context to enrich the notation in order to represent aspects such as the agents' roles or control flows, that we believe are useful for other contexts as well.

Definition 1. *An* instantiation link *of a critical question CQ_k associated to a scheme S is a duple* I_{CQ_k} = (Attack, Support) *where* Attack *is a possibly empty set of schemes $a_1, a_2..., a_n$ and control flows $f_1, ..., f_m$ such that:*

- *For $i = 1...n$, there exist $x_1, x_2, ..., x_r$ and $y_1, ..., y_t$, constants, such that the argument $a_i(x_1, x_2, ..., x_r)$ attacks the argument $S(y_1, ..., y_t)$.*

– f_i *is of the form* (op(F)? A B)*, where* op *is a boolean operator. If* op *validates formula* F*,* f_i *is substituted by* A*, otherwise, it is substituted by* B*. Where* A *and* B *are, in turn, sets, possibly empty, of schemes and control flows. The schemes in both* A B *have the same property of the* a_i *schemes. If* op(F) *evaluates positively* F *and the set A is empty, then the argument instantiating S is defeated.*

Similarly, Support $= \{s_1, s_2, ..., s_u, g_1, ..., g_v\}$*, where* s_i *are argument schemes and* g_i *control flows, such that:*

– *For* $i = 1...u$*, there exist* $x_1, x_2, ..., x_r$ *and* $y_1, ..., y_t$*, constants, such that the argument* $s_i(x_1, x_2, ..., x_r)$ *claim is one of the premisses of* $S(y_1, ..., y_t)$*.*

– g_i*, i = 1,...,v are control flows. Where the schemes in both* A*and* B *have the same property of the* s_i *schemes. If* op(F) *evaluates positively* F *and the set A is empty, the challenge raised by* CQ_k *is answered. Namely, the argument instantiating S is not defeated by the challenge raised by* CQ_k*.*

The *Instantiation Link* of CQ1 of [AEO]: -*Is P an expert in domain D?*-, at this stage could be:

$I_{CQ_1} = (\{\emptyset\}, \{[EbT]\})$[3].

The instantiation link of the CQ3 of [AEO]: -*Is A in domain D?*-, could be:

$I_{CQ_3} = (\{(\texttt{KB}(A \in D)? \ \emptyset \ \emptyset)), \ [AEO]\}, \{(\texttt{KB}(A \notin D)? \ \emptyset \ \emptyset)), \ [AEO]\})$

Where $\texttt{KB}(A \in D)$? is a query to a Knowledge Base.

The instantiation link of CQ4 of [AEO]: -*Is P reliable?*-, could be:

$I_{CQ_4} = (\{[GAH]\}, \{\emptyset\})$

Therefore, in this context, a proponent can make his first move $A1 = [\text{AEO}](john, medicine, mary\_is\_healthy)$. The opponent may then challenge $A1$ via CQ1: *Is john an expert in domain medicine?* to which the proponent may answer $A2 = [\text{EbT}](john, degree\_medicine, medicine)$. The opponent may then use the CQs associated to [EbT] in order defeat or challenge $A2$, or use a CQ associated to [AEO] other than CQ1.

Note that the supporting set of I_{CQ_4} is empty, therefore, given the challenge: -*Is john reliable?*- the proponent has no possible moves. Within the dialog game, if $I_{CQ_k} = (\{\emptyset\}, Support)$ and *Support* is a non empty set, the *burden of proof* is on the proponent, i.e if the opponent raises a challenge via CQ_k the proponent *must* answer to the challenge. Conversely, if $I_{CQ_k} = (Attack, \{\emptyset\})$ and *Attack* is non empty, the *burden of proof* is on the opponent, thus, in our example, the challenge -*Is john reliable?*- is not applicable, the only possible move of the opponent via CQ_4 is $B1 = [\text{GAH}](john)$.

[3] Note that $I_{CQ_1} = (\{[AEO]\}, \{[EbT], [AEO]\})$ is also a possible instantiation link.

If both sets *Attack* and *Support* are empty, the argument acceptability is unresolved. In our context, the Mediator Agent, decides whether the argument is accepted or defeated.

Definition 2. *A Critical Question can be regarded as: -if the formula F is true then the scheme is defeated-. If the Conjunctive Normal Form of the formula F associated to the critical question CQ_k is $F = C_1 \wedge C_2 \wedge ... \wedge C_N$, the* Arity of the CQ_k *is N. (Or, CQ_k is a* N-step critical question*).*

To attack a scheme through an N-step CQ, the opponent has to show $C_1, C_2, ...$ and C_N to be true. To show that C_j is true, the proponent can instantiate an argument scheme $S_{C_j k}$ which claim is C_j[4] or challenge the proponent with *-Is it the case that $\neg C_j$?-* to which the proponent is not be able to answer. We assume that in order to show C_k $(k > 1)$ a player must first show C_{k-1} (C_{k-1} is a precondition to question C_k).

With a N-step CQ comes an Instantiation link of depth N, in which the the first layer of I refers to C_1 and the k layer refers to C_k. Thus we write the instantiation link I of depth N as:

$$I_1 = (\{a_{11}, a_{12}, ..., a_{1n}, f_{11}, ..., f_{1u}\}, \{s_{11}, s_{12}, ..., s_{1m}, g_{11}, ..., g_{1v}\})$$
$$I_2 = (\{a_{21}, a_{22}, ..., a_{2n}, f_{21}, ..., f_{2u}\}, \{s_{21}, s_{22}, ..., s_{2m}, g_{21}, ..., g_{2v}\})$$
$$.....$$
$$I_N = (\{a_{N1}, a_{N2}, ..., a_{Nn}, , f_{N1}, ..., f_{Nu}\}, \{s_{N1}, s_{N2}, ..., s_{Nm}, g_{N1}, ..., g_{Nv}\})$$

Therefore, to answer effectively to a challenge raised by this critical question, the proponent must instantiate effectively one of the s_{jk_j}[5] argument schemes. On the other hand, in order to defeat the argument instantiating the scheme via the N-step CQ, the opponent must instantiate effectively a sequence of argument schemes $a_{1k_1}, a_{2k_2}, ..., a_{Nk_N}$[6]

Let us Take the argument scheme for the viability of a human organ:

VS Viability scheme:
No absolute contraindications were found in donor D (1)
And no absolute contraindications were found in Organ O (2)
And there can be a matching recipient for O (3)
And no logistical problems are expected (4)
And no wrong course of action A is intended (5)
Therefore, organ O is viable. (6)

To this scheme we associate the CQ:

(CQ1) *Does D have Absolute Contraindication C*1 *for donating O?*

[4] Also, C_j could be validated by an operator, for instance, ($\texttt{KB}(C_j)?$ $\emptyset$ B).
[5] If the burden of proof is on the opponent, the proponent does not have to answer.
[6] If, for instance, on level j, the burden of proof is on the proponent, and the proponent is unable to show that $\neg C_j$, then $a_{jk_j} = \emptyset$.

(CQ1) can be regarded as: $donor\_has(D, C1) \wedge contraindication(C1)$? Note that claiming that $donor\_has(D, C1)$ is not a reason to defeat an argument instantiating [VS], neither is claiming $contraindication(C1)$. Thus, the opponent has to first show that $donor\_has(D, C1)$ and then show that $contraindication(C1)$. Conversely, the proponent has to show that either $\neg donor\_has(D, C1)$ or that $\neg contraindication(C1)$.

Before presenting the argument schemes and critical questions repository, we must introduce a new notion into the instantiation link definition:

Definition 3. *Given an instantiation link* $I_{CQ_k} = (\{a_1, .., a_n, f_1, ..., f_u\}, \{s_1, ..., s_m, g_1, ..., g_v\})$ *as defined in definition 1. Then both,* a_i *and* s_j *have the form [S-ID]*$_R$ *where S-ID is the identifier of the scheme, and* R *is a set of roles. This denotes that, only agents that play roles that are in* R *can instantiate [S-ID].*

4 Argument scheme repository to argue over the viability of a human organ

In our context, we can identify three roles: the agent representing the Transplant Coordinator, TCA, the agent representing the Transplant Unit, TUA, and the agent mediating de deliberation, MA. Normally, TCA will start putting forward an argument for viability (resp. non-viability) and TUA will attempt to defeat TCA's claim. It is worth mentioning, that although we are presenting this scenario as *opponent vs. proponent*, it fact, it should be regarded as a collaborative decision making.

Provided that MA can make use of any instantiation of the schemes, we define the role sets: $d = \{TCA, MA\}$ and $r = \{TUA, MA\}$, such that [S-ID]$_d$ (resp. [S-ID]$_r$) are schemes that can only be instantiated from the donor's side (resp. Recipient). If all the agents can instantiate the scheme we will simply write [S-ID].

In our context the control flows we use are:

- ($\texttt{KB}(F)$? A B) where KB is MA's knowledge base. (ACKB and CBRe, see [7])
- ($\texttt{Rep}(F)$? A B) where $\texttt{Rep}(F)$ is the reputation of the agent instantiating the CQ, and F is a dimension of the reputation, i.e. $F \in$ {follow_up, transplant_operation, logistics...}. In general we will write ($\texttt{Rep}$? A B).
- ($commit(F)$? A B), if the agent commits to F then A otherwise, B. In general, we use ($commit(F)$? $\emptyset$ $\emptyset$), thus, for simplicity we write $commit(F)$

A common sequence of control flow, when the CQ has the form -*Is it the case that F?*- is:

($\texttt{KB}(F)$? $\emptyset$ ($\texttt{Rep}$? $commit(F)$ $\emptyset$))

Supposing this is an element of the *Attack* set of an instantiation link, in our context, this means that if the MA's knowledge base validates F the argument instantiating the scheme is defeated. Otherwise, if the agent instantiating this

control flow has good reputation with respect to F it can *commit* to F (or *promise* that F holds, or will hold). But if the agent does not commit to F or it does not have good reputation (w.r.t F) and the MA's knowledge base does not validates F, the argument cannot be defeated through this *Attack* element.

In what follows we enumerate the argument schemes and critical questions of our repository following the proposed formalization.

VS Viability scheme:
No absolute contraindications were found in donor D (1)
And no absolute contraindications were found in Organ O (2)
And there can be a matching recipient for O (3)
And no logistical problems are expected (4)
And No wrong course of action A is intended (5)
Therefore, organ O is viable. (6)

CQ1: Does D have Absolute Contraindication $C1$ for donating O?
I_1: $(\{[PAS]_d, [PACRS]_d\}, \{(\texttt{KB}(common(C1)$[7]$)?\ \{[PAS]_d, [PACRS]_d\}\ \emptyset)\})$
I_2: $(\{[DGFS], [DDTS], [DRFS], [DRFOS]\}, \{\emptyset\})$
CQ2: Does O have Absolute Contraindication $C2$ for being implanted?
I_1: $(\{[OPAS]_d\}, \{[OPAS]_d\})$
I_2: $(\{[OGFS], [ODTS]\}, \{(\texttt{KB}(common(C2))?\ \ [OPAS]\ \ \emptyset)\})$
CQ3: Is there a matching recipient R for O of D?
I: $(\{[NMS]_r\}, \{commit(match)_r\})$
CQ4: Are there expected Logistical Contraindications L ?
I: $(\{[LCS]\}, \{(\texttt{Rep}_r?\ \ \emptyset\ \ commit(\neg L))\})$
CQ5: Is the wrong course of action $A1$ intended on D?
I: $(\{[DCACS]\}, \{(\texttt{Rep}_r?\ \ \emptyset\ \ commit(\neg intended(A1, D)))\})$
CQ6: Is the wrong course of action $A2$ intended on R?
I: $(\{[RCACS1]_r, [RCACS2]_r\}, \{(\texttt{Rep}_r?\ \ \emptyset\ \ commit(\neg intended(A2, R)))\})$

NVS1 Non-Viability scheme (Donor Contra):
Donor D of organ O has C (1)
And C is a an Absolute Contraindications for donating O (2)
Therefore, organ O is non-viable. (3)

CQ1: Does D have C?
I: $(\{\emptyset\}, \{[PAS]_r, [PACRS]_d\})$
CQ2: Is C an Absolute Contraindication for donating O?
I: $(\{[RPDS], [DCES]\}, \{[DGFS], [DDTS], [DRFS], [DRFOS]\})$

[7] The TCA has to show that the donor D does not have property $C1$ only in the case where $C1$ is a common contrainidcation.

NVS2 Non-Viability scheme (Organ Contra):
Organ O has C (1)
And organ O with C cannot be transplanted (2)
Therefore, organ O is non-viable. (3)

CQ1: Does O have C?
I: $(\{\emptyset\}, \{[OPAS]_r\})$
CQ2: Can an organ with C be transplanted?
I: $(\{[RPOS], [OCES]\}, \{[OGFS], [ODTS]\})$

NVS3 Non-Viability scheme (Logistical Contra):
Organ O is expected to arrive to recipient R in time $T1$.(1)
And Organ O's cold ischemia time is $T2$ (2)
$T1 \geq T2$ (3)
Therefore organ O is non-viable. (4)

CQ1: Is the expected time $T1$?
I: $(\{\emptyset\}, \{[LCS]_r\})$
CQ2: Is O's cold ischemia time $T2$?
$F = coldIschemia(O) \leq T2$
I: $(\{(\mathtt{KB}(F)?\ \ (\mathtt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\mathtt{KB}(\neg F)?\ \ (\mathtt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\})$

NVS4 Non-Viability scheme (Procedural Contra on Donor):
Donor D has organ O (1)
And carrying out course of action A on donor during D's procurement phase has as a consequence C on D. (2)
And C is an absolute contraindication for donating O (3)
And A is carried out on D (4)
Therefore, organ O is non-viable. (5)

CQ1: Does A on D has as a consequence C?
$F = \lceil course\_act(A, D) \rightarrow result\_d\_p(D, C) \rceil$
I: $(\{(\mathtt{KB}(F)?\ \ (\mathtt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\mathtt{KB}(\neg F)?\ \ (\mathtt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\})$
CQ2: Is C on D an absolute contraindication?
I: $(\{\emptyset\}, \{[DGFS], [DDTS], [DRFS], [DRFOS]\})$
CQ3: Was A carried out on D?
I: $(\{(\mathtt{Rep}_d?\ \ \emptyset\ \ commit[\neg course\_act(A, D)])\}, \{\emptyset\})$

NVS5 Non-Viability scheme (Procedural Contra on Organ):
Donor D has organ O (1)
And carrying out course of action A on donor during D's procurement phase has as a consequence C on O. (2)
And C is an absolute contraindication for donating O (3)
And A is carried out on D (4)
Therefore, organ O is non-viable. (5)

CQ1: Does A on D has as a consequence C on O of D?
$F = \lceil course\_act(A, D) \wedge d(D, O) \rightarrow result\_o\_p(O, C) \rceil$
I: $(\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\})$
CQ2: Is C an absolute contraindication?
I: $(\{\emptyset\}, \{[OGFS], [ODTS]\})$
CQ3: Was A carried out on D?
I: $(\{(\texttt{Rep}_d?\ \ \emptyset\ \ commit[\neg course\_act(A, D)])\}, \{\emptyset\})$

NVS6 Non-Viability scheme (Procedural Contra 2):
Transplanting organ O from donor D to recipient R (1)
And performing A to R in the post-transplant has as a consequence C on R (2)
And C is harmful. (3)
And course of action A is intended on R (4)
Therefore, organ O is non-viable. (5)

CQ1: Does course of action A on R has as a consequence C on R?
$F = \lceil course\_act(A, R) \rightarrow result\_r\_p(R, C) \rceil$
I: $(\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\})$
CQ2: Is C harmful?
I: $(\{[DCES6], [OCES6], [DCES4], [OCES4]\}, \{\emptyset\})$
CQ3: Is A intended to be carried out on R?
I: $(\{(\texttt{Rep}_r?\ \ \emptyset\ \ commit[\neg course\_act(A, R)])\}, \{\emptyset\})$

NVS7 Non-Viability scheme Match:
There is no matching recipient for organ O (1)
Therefore, organ O is non-viable. (2)

CQ1: Is there a matching recipient R for organ O?
I: $(\{commit_r(match(O, R))\}, \{commit_r(\neg match(O, R))\})$

DGFS Donor Graft Failure Contraindication Scheme:
Organ O of donor D (1)
And organs O of donors with C usually have Graft Failure when transplanted. (2)
Therefore, C is an Absolute Contraindication. (3)

CQ1: Is it really the case of Graft Failure when donors have C?
$F = \lceil d(D, O) \wedge d\_p(D, C) \rightarrow result\_r\_gf(O, R) \rceil$
I: $(\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\})$
CQ2: Does condition $C2$ on recipient R prevent Graft Failure?

I: $(\{[RPGFDS]\}, \{\emptyset\})$

OGFS Organ Graft Failure Contraindication Scheme:
Organ O of donor D (1)
And organ O with C usually have Graft Failure when transplanted. (2)
Therefore, C is an Absolute Contraindication. (3)

CQ1: Is it really the case of Graft Failure when the organ O has C?
CQ2: Does condition $C2$ on recipient R prevent Graft Failure?

DDTS Donor Disease Transfer Contraindication Scheme:
Donor D of organ O has $C1$ (1)
And when transplanting O from donor with $C1$ to recipient R, R may end up having $C2$ (2)
And $C2$ is harmful. (3)
Therefore, $C1$ is an Absolute Contraindication. (4)

CQ1: Is it really the case that R will have $C2$?
$F = \lceil d\_p(D, C1) \rightarrow result\_r\_p(R, C2) \rceil$
I: $(\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\})$
CQ2: Is $C2$ harmful considering R's condition?
I: $(\{[RPCDS], [RPCS]\}, \{\emptyset\})$
CQ3: Is there a course of action A that can prevent R from having $C2$?
I: $(\{[DCAPS]\}, \{\emptyset\})$

ODTS Organ Disease Transfer Contraindication Scheme:
Organ O of donor D with $C1$ (1)
And when transplanting O with $C1$ to recipient R. (2)
And R will have $C2$ (3)
And $C2$ is harmful (4)
Therefore $C1$ is an Absolute Contraindication. (5)

CQ1: Is it really the case that R will have $C2$?
CQ2: Is $C2$ harmful considering R's condition?

The instantiation links are equivalent to the previous scheme

DRFCS Donor Risk Factor Contraindication Scheme:
Donor D of Organ O has RF (1)
And donors having RF are very likely to have C (2)
And C is an Absolute Contraindication for transplanting O(3)
Therefore RF is an Absolute Contraindication. (4)

CQ1: Does D have RF?
I: $(\{\emptyset\}, \{[PAS]_d, [PACRS]_d\})$

CQ2: Do tests show that D does not have C?
I: $(\{\emptyset\}, \{[PAS]_d\})$
CQ3: Is C on D an Absolute Contraindication for donating O?
I: $(\{\emptyset\}, \{[DGFS], [DDTS]\})$

DRFCOS Donor Risk Factor Contraindication on Organ Scheme:
Donor D of Organ O has RF (1)
And donors having RF are very likely to have C on O (2)
And C is an Absolute Contraindication for transplanting O (3)
Therefore RF is an Absolute Contraindication. (4)

CQ1: Does D have RF?
I: $(\{\emptyset\}, \{[PAS]_d, [PACRS]_d\})$
CQ2: Do tests show that O does not have C?
I: $(\{\emptyset\}, \{[OPAS]_d\})$
CQ3: Is C on O an Absolute Contraindication?
I: $(\{\emptyset\}, \{[OGFS], [ODTS]\})$

DCAPS Donor Course of Action Prevention Scheme:
Following course of action $A1$ on donor D and $A2$ on recipient R prevent $C1$ on D result in $C2$ on R (1)
And $A1$ and $A2$ are applied (2)
Therefore R will not result in having $C2$ as a consequence of D having $C1$.(3)

CQ1: Does $A = (A1, A2)$ prevent R from having $C2$?
$F = course\_act(A1, D) \wedge course\_act(A2, R) \rightarrow \neg\lceil d\_p(D, C1) \rightarrow result\_r\_p(R, C2)\rceil$
I: $(\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ \emptyset\ \ commit[\neg F])\ \ \emptyset)\},$
$\{(\texttt{KB}(F)?\ \ \emptyset\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset))\})$
CQ2: Can $A1$ be performed on D?
I: $(\{[DCACS]_d\}, \{\emptyset\})$
CQ3: Can $A2$ be performed on R?
I: $(\{[RCACS1]_r, [RCACS2]_r\}, \{\emptyset\})$

OCAPS Organ Course of Action Prevention Scheme:

The CQs and instantiation links are equivalent to the previous scheme

DCAPGFS Donor Course of Action Prevention GF Scheme:
Following course of action $A1$ on donor D and $A2$ on recipient R prevent C on D result in R having a Graft Failure (2)
And $A1$ and $A2$ are applied (3)
Therefore R will not result in having a Graft Failure as a consequence of donor D of organ O having C.(3)

CQ1: Does $A = (A1, A2)$ prevent R from having a Graft Failure?
$F = course\_act(A1, D) \wedge course\_act(A2, R) \rightarrow \neg\lceil d\_p(D, C) \rightarrow result\_r\_gf(R, O)\rceil$
I: $(\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ \emptyset\ \ commit[\neg F])\ \ \emptyset)\},$
$\{(\texttt{KB}(F)?\ \ \emptyset\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset))\})$
CQ2: Can $A1$ be performed on D?
I: $(\{[DCACS]_d\}, \{\emptyset\})$
CQ3: Can $A2$ be performed on R?
I: $(\{[RCACS1]_r, [RCACS2]_r\}, \{\emptyset\})$

OCAPGFS Organ Course of Action Prevention GF Scheme:

The CQs and instantiation links are equivalent to the previous scheme

RPCS Recipient condition Prevention Contraindication Scheme:
Donor D of Organ O (1)
And Recipient R having $C1$ prevents property
resulting in having $C2$ being a contraindication(2)
And Recipient R has $C1$ (3)
Therefore, R resulting in having $C2$ is not a contraindication.(4)

CQ1: Does R have $C2$?
I: $(\{\emptyset\}, \{[PAS]_r, [PACRS]_r\})$
CQ2: Does $C1$ on R prevent having $C2$ being a contraindication.
$F = r\_p(R, C1) \wedge d(D, O) \rightarrow \neg\lceil result\_r\_p(R, C2) \rightarrow contra(D, O)\rceil$
I: $(\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\})$

RPGFDS Recipient condition Prevention GF on Donor Scheme:
Donor D of Organ O has $C1$ (1)
And Recipient R has $C2$ (2)
And $C2$ on R prevents $C1$ on D of resulting in a Graft Failure on R (3)
Therefore, R will not result in having a Graft Failure because of $C1$ on D(4)

CQ1: Does R have $C2$?
I: $(\{\emptyset\}, \{[PAS]_r, [PACRS]_r\})$
CQ2: Does $C2$ on R prevent having a Graft Failure.
$F = r\_p(R, C2) \wedge d(D, O) \rightarrow \neg\lceil d\_p(D, C1) \rightarrow result\_r\_gf(R, O)\rceil$
I: $(\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\})$

RPGFOS Recipient condition Prevention GF on Organ Scheme:

The CQs and instantiation links are equivalent to the previous scheme

RPDS Recipient Precarious for Donor Property Scheme:
Donor D of Organ O has C (1)
Recipient R is in a precarious condition (2)
And organ O of donor D with C can be transplanted on R if R is in a precarious condition. (3)
Therefore, C is not an Absolute Contraindication for donating O on R. (4)

CQ1: Is C an Absolute Contraindication even if R's condition precarious?
$F = precarious(R) \rightarrow \neg\lceil d\_p(D, C) \rightarrow contra(D, O)\rceil$
I: $(\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\})$

RPOS Recipient Precarious for Organ Property Scheme:

The CQs and instantiation links are equivalent to the previous scheme

DCES Donor Classification Exception Scheme:
Donor D of Organ O has $C1$ (1)
And D has $C2$, a subclass of $C1$ ($C2$ more specific than $C1$) (2)
And $C2$ is not an absolute contraindication. (3)
Therefore, C is not an Absolute Contraindication for donating O in D.(4)

CQ1: Is $C2$ a subclass of $C1$?
I: $(\{(\texttt{KB}(subclass(C2, C1)?\emptyset\emptyset)\}, \{(\texttt{KB}(subclass(C2, C1)?\emptyset\emptyset)\})$
CQ2: Does D have $C2$?
I: $(\{\emptyset\}, \{[PAS]_d, [PACRS]_d\})$
CQ3: Does D have $C3$ subclass of $C1$, and $C3$ is not $C2$?
$F = subclass(C3, C1) \wedge (set(C2) \cap set(C3) = \emptyset)$ [8]
I: $(\{(\texttt{KB}(F)?\ \ \emptyset\ \ \emptyset)\}, \{(\texttt{KB}(F)?\ \ \emptyset\ \ \emptyset)\})$

OCES Organ Classification Exception Scheme:

The CQs and instantiation links are equivalent to the previous scheme

RPCDS Recipient Preferred Condition on Donor Scheme:
Donor D of Organ O has $C1$ (1)
And transplanting O to R may result in R having $C2$
R has $C3$. (2)
And transplanting O to R may result in R not having $C3$ (3)
And having $C2$ is preferable to having $C3$ (4)
Therefore, $C1$ is not an Absolute Contraindication for transplanting O to R. (5)

[8] This could be addressed as a 2-Step Critical Question

CQ1: Does R have $C3$?
I: $(\{\emptyset\}, \{[PAS]_r, [PACRS]_\}$)
CQ2: Is $C3$ preferable to $C2$?
$F = pref\_prop(C1, C2)$
I: $(\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\}$,
$\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\})$

RPCOS Recipient Preferred Condition on Organ Scheme:

The CQs and instantiation links are equivalent to the previous scheme

NMS Non Matching Scheme:
Recipient R has value $V1$ on property $P1$. (1)
And Organ O has value $V2$ on property $P2$ (2)
And If R has $V1$ in $P1$ and O has $V2$ in $P2$ then, O does not match R (3)
Therefore, R does not Match O (4)

CQ1: Does O has value $V2$ in $P2$
I: $(\{\emptyset\}, \{[PAS]_d, [PACRS]_d)\})$
CQ2: Does R has value $V1$ in $P1$
I: $(\{\emptyset\}, \{[PAS]_r, [PACRS]_r)\})$
CQ3: Is it a reason for non matching?
$F = organHas(O, P2, V2) \wedge recipientHas(R, P1, V1) \rightarrow \neg Match(O, R)$
I: $(\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\}$,
$\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\})$

DCACS Donor Course of Action Contraindication Scheme:
Action A is intended on donor D of organ O. (1)
And carrying out A on D may have as an effect C on D (2)
And C is a contraindication for donating O (3)
Therefore, A is a wrong course of action on D for donating O (4)

CQ1: Is A intended on D
I: $(\{(\texttt{Rep}_d?\ \ commit[\neg course\_act(A, D)])\ \ \emptyset\}, \{\emptyset\})$
CQ2: Does A entails C on D?
$F = \lceil course\_act(A, D) \rightarrow d\_p(D, C) \rceil$
I: $(\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\}$,
$\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\})$
CQ3: Is C a Absolute Contraindication.
I: $(\{\emptyset\}, \{[DGFS], [DDTS], [DRFS], [DRFOS]\})$

RCACS1 Recipient Course of Action Contraindication Scheme:
Action A is intended on R to be transplanted with O. (1)
And carrying out A on R may have as an effect C on R (2)
C is harmful. (3)
Therefore, A is a wrong course of action on D for donating O (4)

CQ1: Is A intended on R
I: $(\{(\texttt{Rep}_r?\ \ commit[\neg course\_act(A,R)])\ \ \emptyset\}, \{\emptyset\})$
CQ2: Does A entails C on R?
$F = \lceil course\_act(A,R) \rightarrow result\_r\_p(R,C) \rceil$
I: $(\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\})$
CQ3: Is C harmful considering R's condition.
I: $(\{[DECS6]\}, \{\emptyset\})$

RCACS2 Recipient Course of Action Contraindication Scheme:
Action A is intended on R to be transplanted with O. (1)
And R has $C1$ (2)
And carrying out A on R having $C1$ may have as an effect $C2$ on R (3)
And $C2$ is harmful. (4)
Therefore, A is a wrong course of action on D for donating O (5)

CQ1: Is A intended on R
I: $(\{(\texttt{Rep}_r?\ \ \emptyset\ \ commit[\neg course\_act(A,R)])\}, \{\emptyset\})$
CQ2: Does A with $C1$ entails $C2$ on R?
$F = \lceil course\_act(A,R) \wedge r\_p(R,C1) \rightarrow result\_r\_p(R,C2) \rceil$
I: $(\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\})$
CQ3: Is $C2$ harmful considering R's condition.
I: $(\{[DECS6]\}, \{\emptyset\})$

LCS Logistical Contraindication Scheme:
Problem P may occur during the transplant process of O. (1)
And if P occurs, O's cold ischemia is expected to be $T1$ greater than allowed time $T2$. (2)
Therefore, P is a Logistical Contraindication. (3)

CQ1: Will P occur?
I: $(\{(\texttt{Rep}_r?\ \ commit[\neg logis\_expect(P)]\ \ \emptyset)\}, \{(\ \emptyset\})$
CQ2: Is there course of action A that can prevent P from happening in O's transplant process?
$F = possible\_logis\_act(A) \wedge (logis\_course\_act(A) \rightarrow \neg logis\_expect(P))$
I: $(\{(\texttt{KB}_r(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\texttt{KB}_r(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\})$

PAS Donor Property Affirmation Scheme:
Patient P gave result U on test S (1)
And having result U on test S entails that patient P has C. (2)
Therefore, P has C. (4)

CQ1: Is U a conclusive result for test S?
$F = result(S, U) \rightarrow \neg\lceil test(S) \rightarrow has(P, C)\rceil$
I: $(\{[PNS2], (\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\})$
CQ2: Is S a reliable test to test C on P?
$F = \lceil positiveTest(S, C) \rightarrow has(P, C)\rceil$
I: $(\{[PNS1], (\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\})$

OPAS Organ Property Affirmation Scheme:

The CQs and instantiation links are equivalent to the previous scheme

PACRS Donor Property Affirmation based on Clinical Records Scheme:
Clinical records state that patient P has property C (1)
Therefore, P has C. (2)

CQ1: Does test T shows that P does not have C?
$F = common(T) \wedge dataOf(T, C)$
I: $(\{[PAS]\})$, $\{(\texttt{KB}(F)?\ \ [PAS]\ \ \emptyset)\})$

PNS1 Property Negation Scheme:
Patient P gave result U on test S (1)
And result U on test S is not conclusive result to determine C on P (2)
Therefore P may not have C. (3)

CQ1: Is there another test $S2$ that concludes that P has C?
I: $(\{[PAS]\}, \{\emptyset\},)$
CQ2: Is test S unreliable?
$F = \lceil positiveTest(S, C) \rightarrow has(P, C)\rceil$
I: $(\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\})$

OPNS1 Organ Property Negation Scheme:

The CQs and instantiation links are equivalent to the previous scheme

PNS2 Property Negation Scheme:
Patient P gave result U on test S (1)
Test S is not a reliable test to determine C on P (2)
Therefore D may not have C. (3)

CQ1: Is S unreliable for determining C on D?
$F = \lceil positiveTest(S, C) \rightarrow has(P, C)\rceil$

I: $(\{(\texttt{KB}(\neg F)?\ \ (\texttt{Rep}?\ \ commit[F]\ \ \emptyset)\ \ \emptyset)\},$
$\{(\texttt{KB}(F)?\ \ (\texttt{Rep}?\ \ commit[\neg F]\ \ \emptyset)\ \ \emptyset)\})$
CQ2: Is there another test $S2$ that concludes that D has C?
I: $(\{[PAS]_d\}, \{\emptyset\})$

OPNS2 Organ Property Negation Scheme:

The CQs and instantiation links are equivalent to the previous scheme

We know give two short dialog examples in which the agents make use of the argument schemes and critical questions:

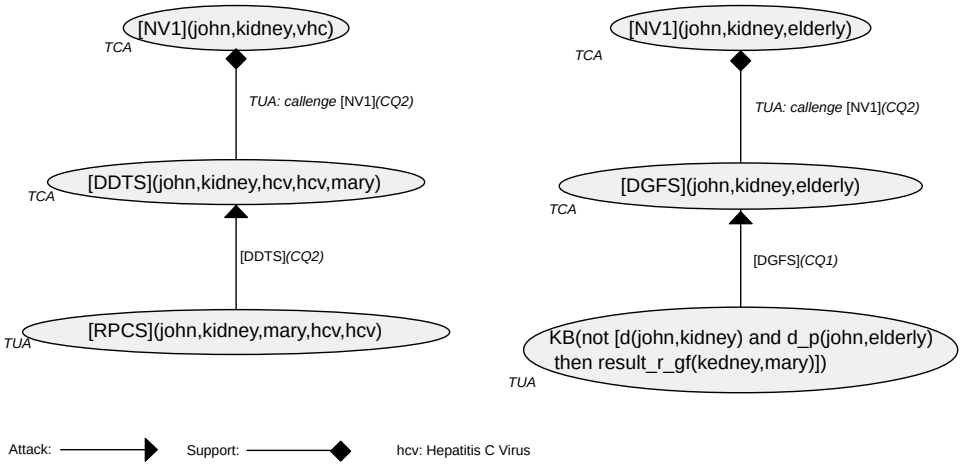

Fig. 1. A TCA offers the organ as non-viable, the TUA contra-argues claiming that kidney is viable because its patient also has *hepatitis C*, and it does not believe that a kidney of an *elderly* person should be discarded, which is supported by the MA agent.

5 Conclusion

In this report we present a novel formalization of argument schemes and critical questions in order to enable agents to argue over the viability of a human organ. The most similar work we have found in the literature is the *PARMA protocol* [1], which is a multi-agent dialogue game protocol that enables argument over proposals for action. The argument schemes and the attack relations to an argument involved in this protocol have a rather high level reasoning representation (e.g. attack relations are formalized as sentences like *Disagree with the description of the current situation* or *Disagree that the desired value is worth promoting*). Our

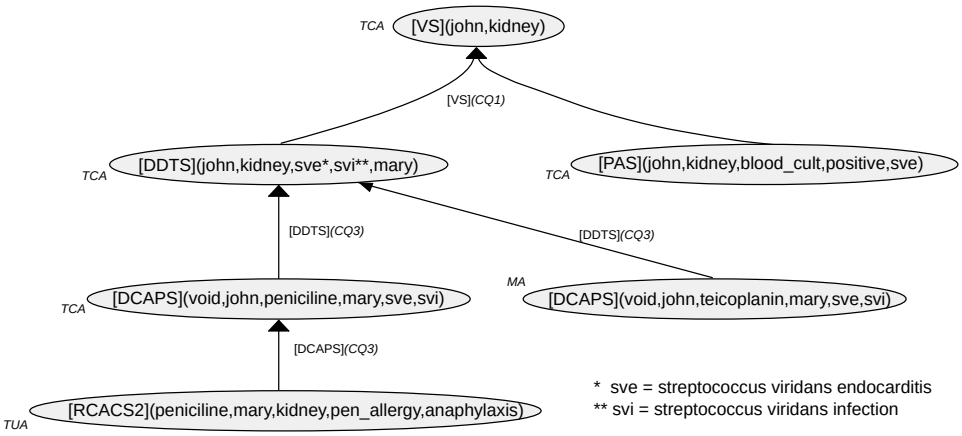

Fig. 2. In this dialog the TCA argues that the organ is viable if the recipient is administrated with *penicillin*. The TUA contra-argues claiming that it cannot administrate *penicillin* to its patient given that she is allergic, thus it may cause her to have anaphylaxis. The MA then propose to administer *teicoplanin*.

proposal is somewhat less general, but we believe it to be readily implementable. Moreover, we believe our formalization to be expressive enough as to capture a wide range of deliberative scenarios, as long as there is a *reduced* number of *concrete* reasoning patterns that can capture the overall deliberative process.

Within argumentation theory, argument schemes are a standard way with which to encode rules. We regarded argument schemes as being coherent with our previous work and formalization [7] and [3]. There are two other aspects that motivated our use of argument schemes and critical questions:

– "By explicitly handling argumentation schemes it becomes possible for agents to at once broaden the scope of the relevant information, and at the same time, narrow down selection on the basis of the argument schemes detected" [5]. In other words, agents are directed by the CQ in order to further support their arguments or to attack an argument that they disagree with. Note that not all disagreements are logically derivable (in a straight forward way), for example [DCAPS]CQ3-*Can A2 be performed on R?*-. Also not all the possible logical disagreements are applicable in certain contexts (e.g. in scheme [VS] there is no point in putting forward the challenge -*Is O D's organ?*- despite being a valid challenge from a logical point of view)
– Argument Schemes and Critical Questions provide us with a useful conceptual framework in which to elicit the required argumentation knowledge from physicians with experience in deciding the viability of human organs. The pseudo natural language used to represent this defeasible rules (argument schemes), and their defeaters (critical questions) enable to readily compre-

hend the content of these rules and propose new rules or changes in the existing ones.

In both, [7] and [3], we address the agents argument based deliberation as a three step process, in which a TCA provides its arguments, then TUA contra-argue and finally, MA evaluates the arguments, being able also to add its own arguments. This process does not conflict with the argument scheme formalization at hand, since, as we pointed out above, critical questions not only identify the defeaters of an argument, but also the lines of reasoning that enable to further support a given argument. Also in [3] we express our intention to address the agents' deliberation from a dialogical perspective.

Acknowledgments This report was supported in part by the Grant FP6-IST-002307 (ASPIC).

References

1. K. Atkinson, T. J. M. Bench-Capon, and P. McBurney. Implementation of a Dialogue Game for Persuasion over Action. Technical Report ULCS-04-005, University of Liverpool, 2004.
2. K. M. Atkinson, T. J. M. Bench-Capon, and P. McBurney. A dialogue game protocol for multi-agent argument for proposals over action. In *Proc. First International Workshop on Argumentation in Multi-Agent Systems (ArgMAS 2004)*, 2004.
3. S. Modgil, P. Tolchinsky, and U. Cortés. Towards formalising agent argumentation over the viability of human organs for transplantation. Submitted to the MICAI conference, 2005.
4. J. L. Pollock. Defeasible reasoning. *Cognitive Science*, 11:481–518, 1987.
5. C. Reed and D. Walton. Applications of argumentation schemes. In *Proceedings of the 4th OSSA Conference*, 2001.
6. Chris Reed and Douglas Walton. Towards a formal and implemented model of argumentation schemes in agent communication. In Iyad Rahwan, Pavlos Moraitis, and Chris Reed, editors, *ArgMAS*, volume 3366 of *Lecture Notes in Computer Science*, pages 19–30. Springer, 2004.
7. P. Tolchinsky, U. Cortés, J.C. Nieves, F. Caballero, and A. López-Navidad. Using arguing agents to increase the human organ pool for transplantation. In *3rd Workshop on Agents Applied in Health Care (IJCAI-05)*, 2005. Accepted.
8. J. Vázquez-Salceda, U. Cortés, J. Padget, A. López-Navidad, and F. Caballero. The organ allocation process: a natural extension of the CARREL Agent-Mediated Electronic Institution. *AiCommunications*, 3(16), 2003.
9. Bart Verheij. Dialectical argumentation with argumentation schemes: An approach to legal logic. *Artif. Intell. Law*, 11(2-3):167–195, 2003.
10. D. N. Walton. *Argumentation Schemes for Presumptive Reasoning.* Lawrence Erlbaum Associates, Mahwah, NJ, USA, 1996.
11. D.N Walton. *Ad Hominem Arguments.* Tuscaloosa: The University of Alabama Press, 1998.